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The Biggest Rain Events Ever

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While Hurricane Harvey was intensifying in the Gulf of Mexico, it was pretty obvious that somebody was going to get a ton of rain. As it turns out, the highest rainfall total credibly measured by a rain gauge was 60.58” in Nederland, in the southeast corner of Texas (Blake and Zelinsky 2018). That’s five feet of rain.*

As Harvey was happening, I had a hunch that it could break some multi-day rainfall records. So I looked the records up. It turns out there isn’t an official list list of multi-day rainfall records for the United States. There was, however, an official record for greatest rainfall total from a tropical cyclone, set a long time ago on the Hawaiian Islands, which Harvey handily beat after a few days. Within the year, another storm hit the Hawaiian Islands with an even larger rainfall total than Harvey, so the record’s back where it came from.

That much rain in a short period of time will overflow the rain gauge, but that’s only a problem for weather data geeks like myself. The bigger problems happen when the heavy rain falls over a large area. And then keeps falling.

A map of total rainfall from Harvey is truly impressive. At its normal flow rate, it would have taken the mighty Mississippi River three days to drain all the water dumped on Harris County during Harvey. Since there wasn’t a Mississippi River available to dispose of all the water, massive flooding resulted.

I wondered, how does Harvey stack up against the biggest rain events ever documented in the United States? And which events were they? Do they normally happen in the southern United States? Or were we just lucky?

To figure out the total amount of rain in a given area, I needed what are called rainfall

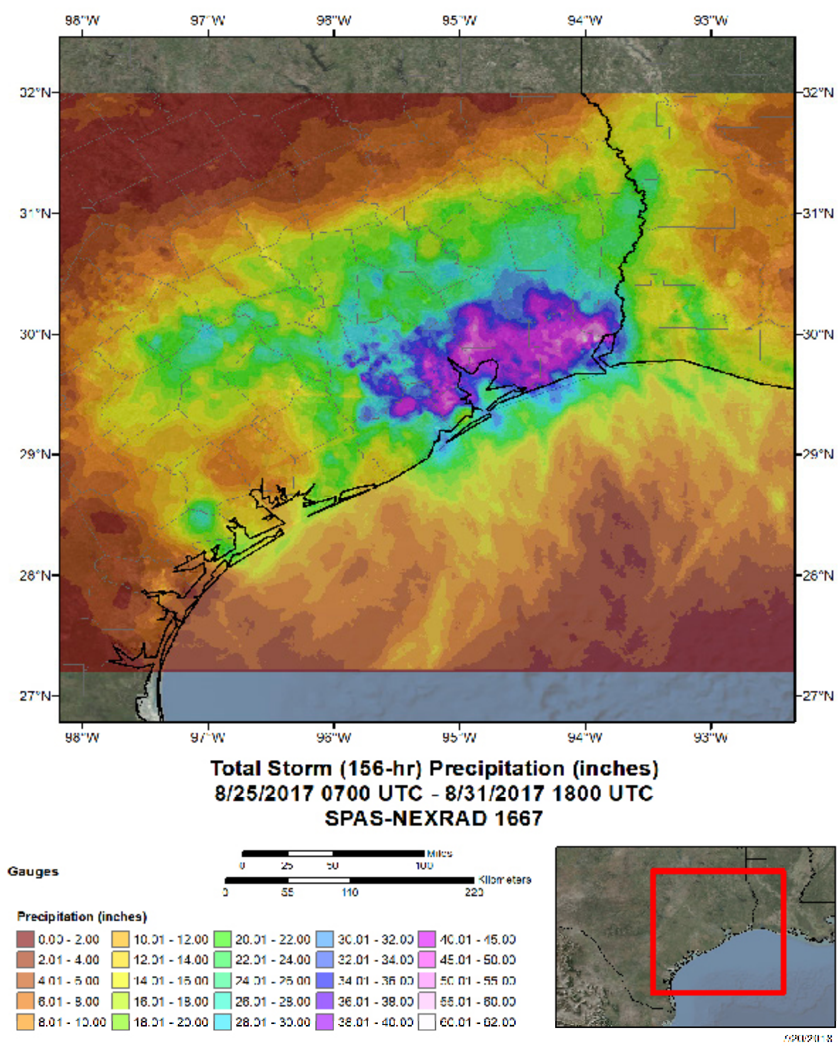

Figure 1: Integrated Harvey rainfall analysis by Applied Weather Associates, based on integrated radar and gauge measurements.

"analyses": maps of the distribution of rainfall. During the road- and dam-building eras of the early to mid 20th century, special maps were produced after every big rainstorm. Engineers needed to know how much rain could fall over a given area, and how big a storm could be expected during the lifetime of the road or dam. So there's a nice collection of analyzed heavy rainfall events from which I can crudely estimate things like how much rain fell over three days in a 10,000 square mile area.

The need for such analyses continues, but now humans can combine with computers to do the work much more efficiently. The result is a "gridded" analysis of precipitation, meaning that average precipitation totals are estimated on a regularly-spaced grid, like the squares formed by a screen. This made my job much easier: I could just figure out how many squares it took to make 10,000 square miles and calculate the amount of rain over that many squares. One of the companies I worked with on the Harvey rainfall analysis, Applied Weather Associates (AWA), happened to have an archive of analyses that they'd performed of some big events of the past, in order to estimate the risk of extreme rainfall in particular locations.

Another use for analyses of rainfall is to understand impacts on soil moisture and plants. In recent years, the impact of climate change on soil moisture and plants has become an important issue, so a team from the western United States (Livneh et al. 1913) developed a set of temperature and rainfall analysis going back all the way to 1915. While they analyzed everything, not just the heavy rain events, I could pull out the heavy rain analyses and make use of them.

The Livneh analyses include data through the year 2011, so I still needed more recent analyses. Fortunately, such analyses are produced by several groups. I made use of analyses from the Northeast Regional Climate Center that use radar and rain gauge data over the central and eastern United States over the past 15 years and rain gauge data over all of the United States going back to 1950.

With all these analyses, I had access to data from all storms since 1913 in the lower 48 states as well as a handful before 1913. I even had multiple analyses for some storms. And often, those analyses did not agree.

One notable case was a slow-moving tropical storm that hit southern Louisiana in August 1940 (Roth 2010). Several stations in the area recorded more than two feet of rain in just a couple of days. My analysis from AWA had the Louisiana 1940 storm rivalling Harvey for a two-day event over 1,000 square miles (Figure 2). But the Livneh analysis had only about half the rainfall amount, making the Louisiana storm irrelevant.

Seeing this, I decided to look at the data for myself and do my own analysis. An online data interface was frustrating, because most of the data was missing during what should have been the heaviest part of the storm.

Figure 2: Map of rankings of biggest known rainstorms in United States history, according to the number of times they appear in the top five all-time lists for a range of number of days and area sizes.

Digging into the raw archive, I found that this data was present but had been flagged by the quality control algorithm for being suspicious. The Livneh analysis had apparently accepted the quality control flag and tossed out the suspicious data. Since all the one-of-a-kind data had been ignored, the resulting analysis was not of a one-of-a-kind rainstorm.

I was able to alert the data archivers of this issue, so they went in and manually overrode the quality control algorithm. When future scientists analyze the event using the computerized data, they'll have access to all of it.

With analyses compiled and reconciled, it was time to do the rankings. I looked at areas ranging from 1,000 sq mi to 50,000 sq mi and event lengths from 2 days to 5 days: 18 different rankings in all. And in every single category, Harvey was the winner! In some categories, Harvey produced 30% more rainfall than its nearest rival.

When it gets interesting is with the Avises of the rainfall world, those who come in second even though they try harder. Most often second was the "Christmas Flood", an atmospheric river event that hit Oregon and California in December 1964 and easily defeats all others (except for Harvey) for events lasting five days (USGS 1964). Atmospheric rivers are long, thin tongues of atmospheric moisture that emanate from the tropics and subtropics and produce lots of rain when they make landfall.

All other second-place events were along the Gulf or Atlantic coasts: Hurricane Georges in 1998 (Mississippi, Alabama, and Georgia), Hurricane Floyd in 1999 (North Carolina to Delaware), and Hurricane Florence in 2018 (the Carolinas), in addition to the 1940 event in Louisiana. Expand the list to top threes and we only need to add three more storms: a California atmospheric river in 1955, Hurricane Beulah in 1967 (Texas) and the 1899 Hearne storm (also in Texas).
The map shows the locations of all storms that made at least one of my eighteen top 5 lists, along with ranking on the "appears on most top 5 lists" list. Harvey, of course, appears on all 18, so it's #1. A poor little storm like Claudette in 1979 only shows up on one list, so it ranks near the bottom of this highly selective group. Claudette, by the way, held the record for greatest one-day precipitation total in the United States until yet another Hawaiian storm last year eclipsed it.

Just about every storm on this list was associated with a tropical storm or hurricane, except for the west coast ones. Tropical storms and hurricanes aren't guaranteed to produce record amounts of rainfall, but they certainly make it possible.

So if you want lots and lots of rain, you've got two options: the Gulf or southeast Atlantic coasts in summer or early fall when a tropical cyclone hits, or the Pacific coast in winter when an atmospheric river hits. And don't forget your chaise lounge.

Footnotes

*Here's an amazing fact for the next time you're short on conversation topics in a bar. A typically-sized adult, lying down, has a surface area of about 7 square feet. If this adult had chosen to relax outside Nederland on a chaise lounge on the morning of August 25, 2017, and wait out Harvey, they would have been hit by 35 cubic feet of rainwater. Since the density of water is a bit more than 60 pounds per cubic foot, this person would literally have gotten a ton of rain. :)

**See previous footnote.

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NOAA's Atlantic Hurricane Season Outlook

Margret Boone, SCIPP Program Manager

On May 23, 2019, the NOAA Climate Prediction Center (CPC) released the Atlantic Hurricane Season Outlook. The Atlantic Hurricane Season runs from June 1 to November 30, though tropical storms and hurricanes have occurred outside of that time frame. The Hurricane Outlook reflects the probability of tropical storm and hurricane development in the North Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico, but it does not reflect the probability of these storms making landfall.
The 2019 Atlantic Hurricane Season Outlook indicates there is a 70% probability of 9-15 Named Storms, 4-8 Hurricanes, and 2-4 Major Hurricanes (Fig. 1). This translates to a 40% chance of a near-normal season, a 30% chance of an above-normal season, and a 30% chance of a below-normal season. -

NOAA's Climate Prediction Center considers the El Niño Southern Oscillation (ENSO) and Atlantic Sea Surface Temperatures when preparing the outlook. Currently, ongoing El Niño conditions are expected to persist in the Pacific Ocean and warmer than average sea surface temperatures continue in the Atlantic hurricane main development region (i.e. the tropical Atlantic Ocean and Caribbean

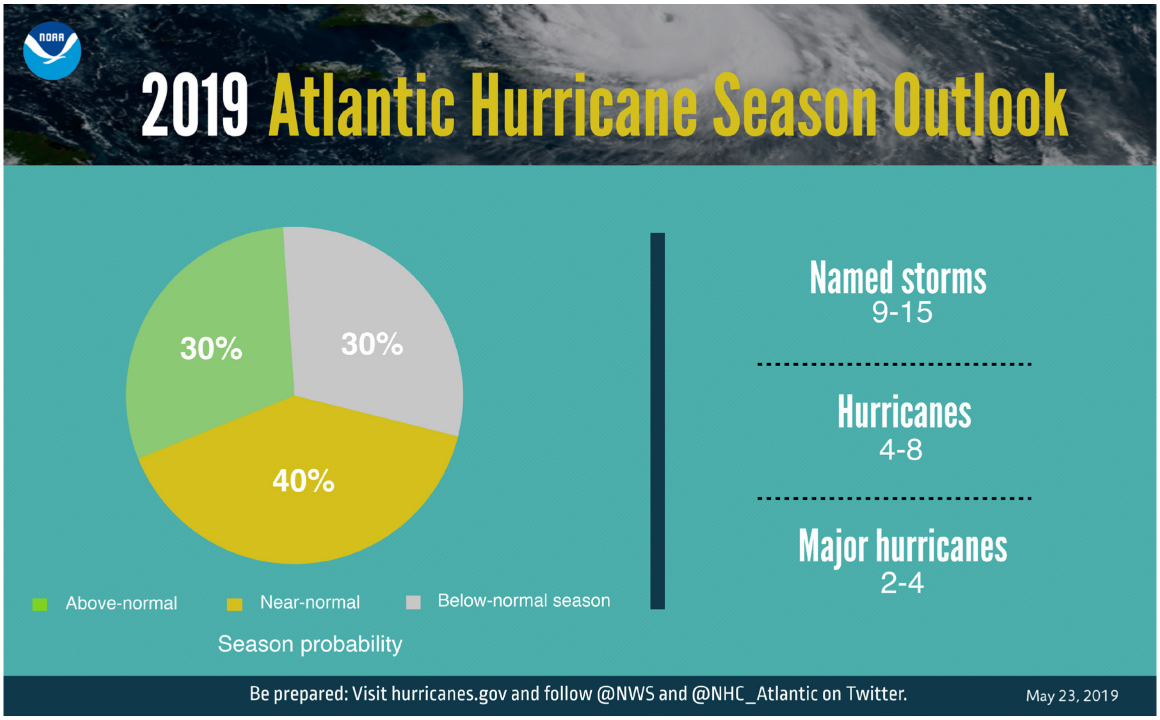

Figure 1: Hurricane season probability and numbers of named storms. (NOAA) Image courtesy (https://www.noaa.gov/media-release/noaa-predicts-near-normal-2019-atlantic-hurricane-season)

Sea). Warmer sea surface temperatures and an enhanced west African monsoon are both favorable conditions for hurricane activity.

This year marks the first year NOAA has 3 next-generation satellites operational. These satellites will provide valuable data for forecasters, as well as enhance the current hurricane models. Also new this year, the NOAA National Weather Service will upgrade the Global Forecast System, or GFS, weather model. This will be the first major upgrade in nearly 40 years, and will be crucial for this upcoming hurricane season.

NOAA's Hurricane Outlook will be updated in early August, prior to the peak of the hurricane season. Figure 2 shows a list of the Atlantic tropical cyclone names for 2019. Andrea formed early in 2019, so the next tropical storm will be Barry.

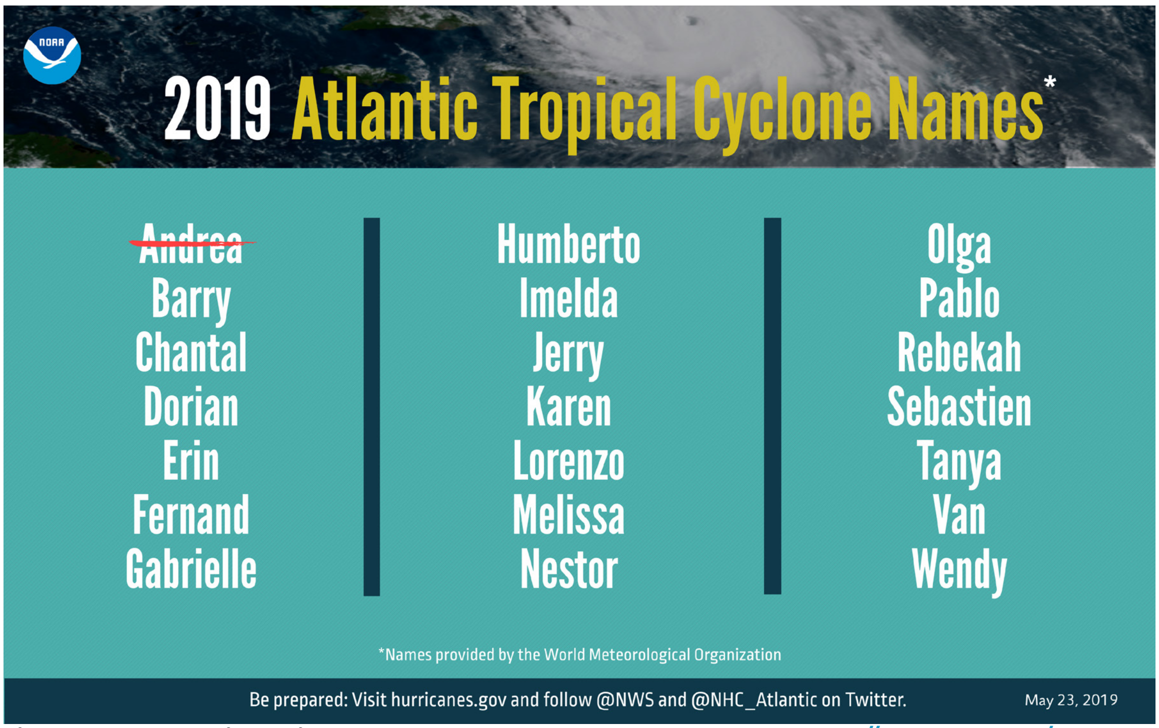

Figure 1: 2019 Atlantic tropical cyclone names. (NOAA) Image courtesy (https://www.noaa.gov/media-release/noaa-predicts-near-normal-2019-atlantic-hurricane-season)

Managing the Costs of Disasters

Mark Shafer, Director of SCIPP

When you file an insurance claim, you have to pay a deductible before insurance covers remaining costs. FEMA is considering implementing something similar for Federal disaster assistance. Currently, the Federal government covers at least 75% of all eligible costs, once a damage threshold has been met, with states and local governments covering the remaining amount. A deductible would require the state or tribe to cover more costs up-front before Federal assistance would kick in.

So why is FEMA considering such a change? The reason is that both the number of disasters and costs of disasters have risen drastically in recent years. Large events such as Hurricane Harvey or recent flooding have proven very costly, exceeding the funding allocated to FEMA each year. Consequently, FEMA is looking for ways to preserve its funds for the most exceptional cases.

Disaster Declaration Policy

The Disaster Relief Act of 1950 was a milestone in an emergent role of the Federal government in disaster management. Up until that time, any Federal assistance required authorization by Congress on a case-by-case basis. These were rare, such as the 1927 Mississippi River flood that covered 27,000 square miles and caused massive social disruption across 10 states, including all of those within the SCIPP region. The Disaster Relief Act moved the declaration process to the executive branch, with the President determining when assistance was needed.

Throughout the first two decades of this new structure, such declarations were fairly rare, with about 15 per year on average. Beginning in the 1970s this began to grow, peaking at nearly 50 declarations in 1972 before returning to a level closer to 25 per year in the later 1970s and 1980s. By the 2000s, the average had risen to over 50 declarations per year, peaking at 99 in 2011. How many of these events truly need Federal assistance compared to what prior to 1950 had been state, local, and charitable responsibilities?

One reason that there were relatively few declarations in the first few decades is that decisions of what qualified as a Federal disaster were seen as somewhat arbitrary, in that there were no clear criteria used to judge whether state and local capacity to manage the event had been exceeded. The Robert T. Stafford Disaster Relief Act of 1988 sought to formalize the process. The Stafford Act

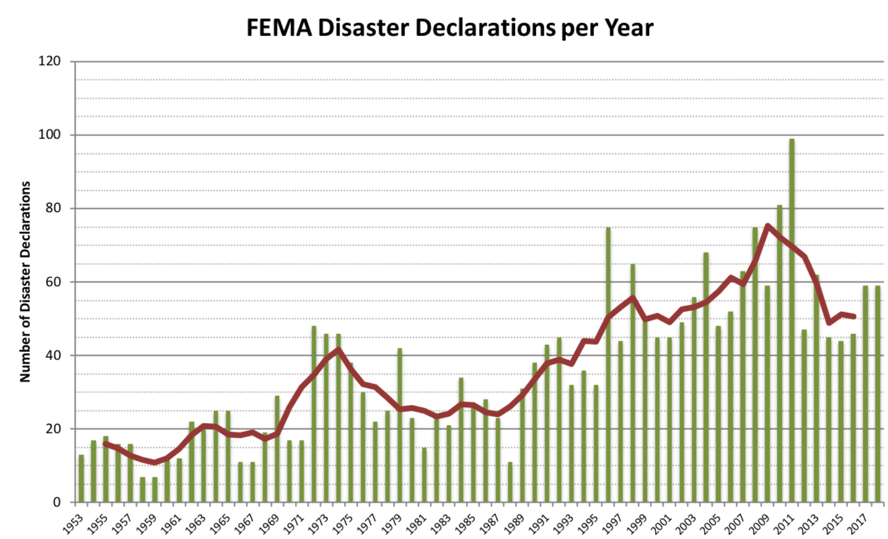

Figure 1: Number of Major Disaster Declarations per year (green bars) with a 5-year running average (red line).

created a comprehensive approach to disaster management, in which states (and later tribes) must document damage to infrastructure to qualify for Federal assistance.

The Federal Emergency Management Agency (FEMA) was created to administer such requests, make determinations regarding deployment of Federal resources, and coordinate activities across dozens of Federal agencies. Assistance was provided as Public Assistance (PA), which assists with public infrastructure restoration, or Individual and Household Assistance (IA) that provides a basic level of mortgage and rent assistance and funds for minor repairs, up to $28,000 household limit. It also created a Hazard Mitigation Grant Program (HMGP) that adds 15% of PA costs for additional mitigation projects.

The administrative processes and priorities have evolved since the Stafford Act was established in 1988, but the overall framework remains unchanged. The Disaster Mitigation Act of 2000 added a requirement for states and local governments to create multi-hazard mitigation plans as an eligibility requirement for HMGP mitigation project funding. It also established a Pre-Disaster Mitigation Program. FEMA was moved to the new Department of Homeland Security in 2002 and took on a larger role in preparing for human-caused disasters. Challenges of communication and coordination were uncovered during Hurricane Katrina, resulting in a Post-Katrina Disaster Emergency Management Reform Act in 2006, which re-established FEMA as a distinct entity within DHS, allowed limited federal action without a state's request, and created a National Disaster Recovery Strategy.

Potential Policy Changes

Any change in policy has positives and negatives. Shifting more responsibility to state and local government should, in theory, promote resilience because with less access to Federal assistance, states can take actions to encourage resilience to reduce impacts on state budgets. Converting to loans should similarly encourage states to pursue more mitigation actions, knowing that Federal assistance would have to be repaid. But such policies also run the risk of going back to a pre-1950 framework, where assistance was often unavailable from any source, leaving communities on their own to cope.

In 2017, FEMA sought comments on an approach to implementing a state deductible. A deductible would be determined for each state based upon the state's fiscal capacity and disaster risk and a proposed credit structure to reward states for undertaking resilience-building activities. For example, states implementing stronger building codes, land-use planning, or establishing their own emergency funds could get credits to offset some of the deductible. Over time, mitigation actions would reduce exposure to extreme weather events, making fewer requests necessary.

FEMA's proposal included that each state would be expected to expend a predetermined, annual amount of its own funds on emergency management and disaster costs before FEMA would provide Public Assistance for repair and replacement of public infrastructure damaged by a disaster event. Debris removal and emergency protective measures would be exempt from the deductible. States could also earn credits through activities that could reduce risk and improve preparedness.

Deductibles for each state would be based on an index of state risk and fiscal capacity. After adjusting for potential credits, based on current activities, FEMA estimated that deductibles in the first year would range from $300,000 in North Dakota to $27 million in Texas. Deductibles in other SCIPP states would be $2.49 million in Arkansas, $3.33 million in Oklahoma, and $5.57 million in Louisiana. FEMA proposed the concept for public comments, but has not yet chosen if it will move toward implementation.

Evaluating Heat Related Illnesses in Louisiana

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Barry Keim and Rachel Riley, SCIPP

Exposure to hot and humid temperatures is not rare in Louisiana but predicted increases in surface temperatures due to climate change will likely make heat exposure a more pressing public and occupational health issue. In the southeastern United States, average annual temperatures have increased by about 2°F since 1970 with the greatest warming occurring during summer, and by the end of the century temperatures are projected to increase by 4°F to 8°F in this region with more predicted days over 95°F (Melillo et al. 2014; Green et al. 2011). Population susceptibility to extreme heat is influenced by multiple factors including age, socio-economic disparities, living conditions and occupation (McGeehin and Mirabelli 2011; Sailor et al. 2002; Zhou et al. 2014). Understanding these state level variations is critical to identifying high risk subpopulations and directing public health resources to prevent heat-related illness (HRI), including development of accurate and targeted heat warning systems (Melillo et al. 2014).

SCIPP has been collaborating with the Louisiana Department of Health to characterize cases of HRI treated in an emergency department or hospital in Louisiana. Initial analysis was completed for a 2-year period during 2010 and 2011 which were exceptionally hot years for the state. The year 2011 was the warmest year on record for Louisiana; 3.54°F above normal with record keeping dating back to 1895, in addition to record-breaking heat in 15 parishes, and 29 broken heat records (Natural Resources Defense Council, 2012). The average temperature for summer of 2010 was 2.67°F above normal and was the third warmest summer on record.

Preliminary results of the 2010-2011 study, the first in-depth analysis of heat-related illness in Louisiana, provided a comprehensive assessment of the impact of heat on vulnerable sub-populations throughout the state. This information is critical to the development of prevention and adaptation strategies related to hot temperatures. During the study period there were 5,436 cases of heat-related illness with a mean annual rate of 60 cases per 100,000 residents. Figure 1 shows the HRI count and rate by age group for 2010-2011. About 85% were treated in the emergency department. Significantly elevated rates were observed among males, African-Americans, individuals aged 20-49 years, and in the Northwest region of the state. Average lengths of hospitalization were greatest for the youngest and oldest age groups. About 25% of the cases had at least one-comorbid diagnosis; differences in age group ranged from 13-15% among cases under 20 years to 57% of cases 80 and older. Cardiovascular disease was the most common co-morbid diagnoses (8.3%).

SCIPP is continuing to work with the Louisiana Department of Health to expand the study to include the years 2000-2018 and to compare HRIs and heat index value by climate division (CD). There are nine CDs in Louisiana.

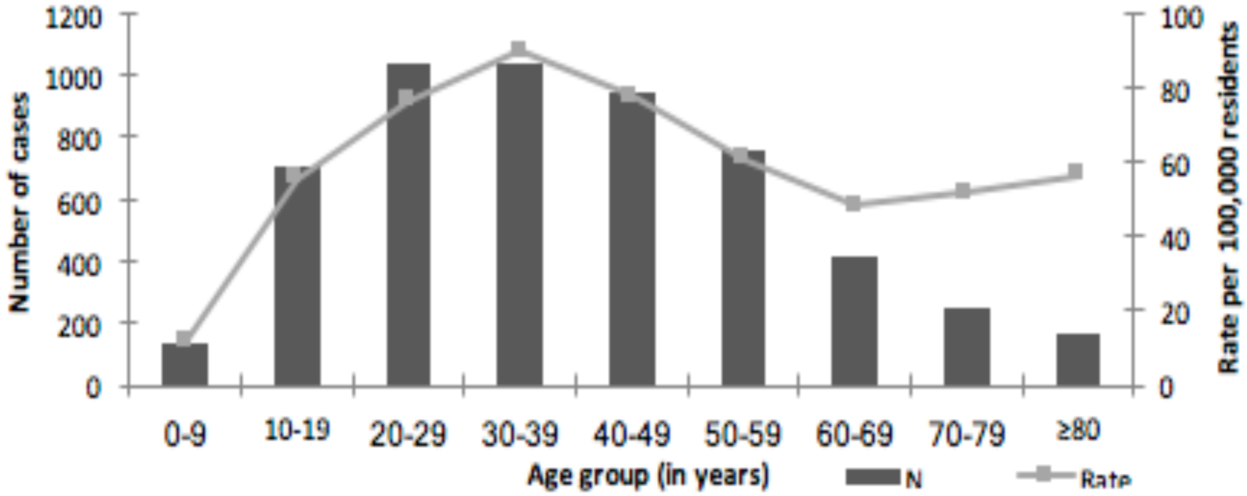

Figure 1. Count and rate of heat-related illness by age group, Louisiana 2010-2011*

* U.S. Census data were used for annual populations and rate calculations.

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20 Years Later: The May 3-4, 1999 Southern Plains Tornado Outbreak

Margret Boone, SCIPP Program Manager

May 3rd, 1999, began like any other Spring day in the Southern Plains. The morning was cloudy, as southerly winds overnight brought moisture northward from the Gulf of Mexico. The dryline — a classic location for thunderstorm initiation — was located roughly north to south across western Oklahoma. Forecasters were already watching the potential for thunderstorms that day. The Storm Prediction Center (SPC) had much of the Southern Plains in a slight risk during the morning.

By mid-morning to early afternoon, cloud cover had begun to clear ahead of the dryline as it pushed eastward. Forecasters at the National Weather Service in Norman, Oklahoma and SPC were monitoring the changing conditions, realizing that a severe thunderstorm outbreak was becoming possible. By the mid-morning convective outlook, SPC had upgraded the slight risk for severe thunderstorms to a moderate risk, covering much of Oklahoma, southern Kansas, and north-central Texas. Ingredients were coming together for a potential significant severe weather outbreak with all hazard types: wind, hail and tornadoes.

As the afternoon progressed, instability continued to increase with decreasing clouds and increasing temperatures, along with the moisture return that had started overnight. A special weather balloon released around 1 PM CT suggested there was extreme instability across the region, especially near the dryline, and that the cap was weakening. Armed with this information, the SPC upgraded the afternoon outlook to a high risk across most of Oklahoma, southern Kansas and north-central Texas. Forecasters used words like "strong or violent tornadic supercells" given the atmospheric conditions by mid-afternoon.

Storms initiated ahead of the dryline in southwestern Oklahoma between 3:30 and 4 PM. The first tornado warning of the day was issued around 4:45 PM. This would be the first of many tornado warnings issued throughout the evening and overnight.

As thunderstorms continued to form, rotate and become supercells, it became obvious that some of the supercell storms would reach the Oklahoma City metropolitan area. A tornadic supercell entered the outskirts of the Oklahoma City area around 6:30 PM. As the tornado showed signs of intensifying, forecasters at the NWS Norman Office issued a new tornado warning, a 'Tornado Emergency', as a way to indicate the danger associated with this life-threatening situation. This was the first tornado emergency tornado warning issued, and as a result of this severe weather outbreak day, the use of tornado emergency is now a part of tornado warning protocol at the NWS.

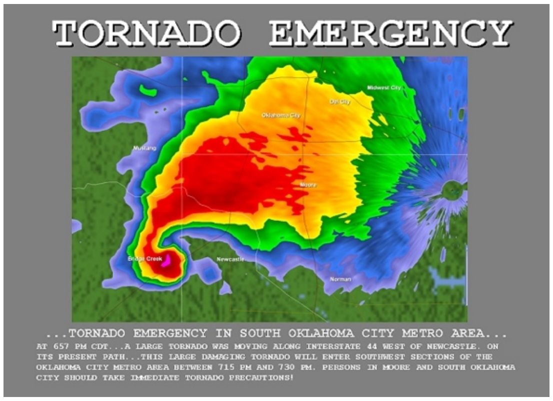

Figure 1: Messaging used for the tornado emergency that was issued for Oklahoma City on May 3, 1999.

The May 3-4, 1999 Tornado Outbreak is still the largest tornado outbreak in Oklahoma history. A total of 63 tornadoes touched down from southwest Oklahoma into portions of eastern Oklahoma on May 3, with an additional 9 tornadoes during the morning of May 4. The most infamous tornado was the F5 Bridge Creek-Moore-Oklahoma City tornado, the same tornado that prompted the 'Tornado Emergency'. The graphic below, courtesy National Weather Service in Norman, Oklahoma, shows the tracks of the 58 tornadoes that occurred in the NWS Norman forecast area.

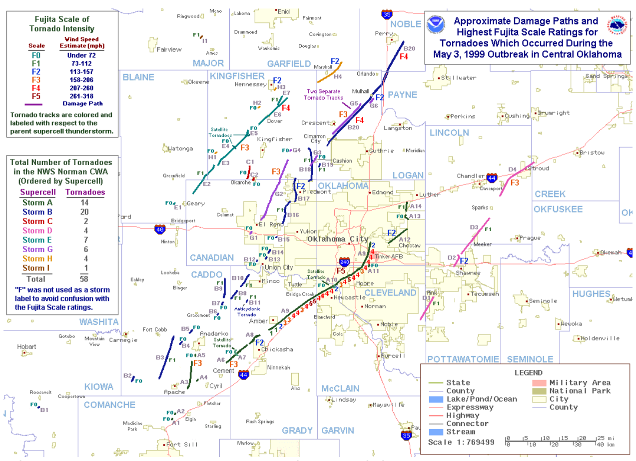

Figure 2: Tracks and peak intensities of tornadoes across central Oklahoma during the May 3-4, 1999 tornado outbreak.

Of the 58 tornadoes in central Oklahoma, there was 1 F5 tornado and 2 F4 tornadoes. In Oklahoma, 40 people lost their lives and 675 were injured. Several tornadoes occurred in Kansas as well, where 5 people were killed and 100 injured in the Wichita area.

As mentioned above, this tornado outbreak saw the creation of the 'Tornado Emergency', a rare tornado warning used to indicate a large and violent tornado is on the ground, and catastrophic and life-threatening damage is possible. This tornado outbreak also spawned a wave of awareness regarding personal storm shelters. There are now many different companies offering installation of storm shelters (above and below-ground) in the state of Oklahoma and around the Southern Plains. Some areas offer storm shelter, or safe room, rebate programs. Oklahoma offers SoonerSafe, a safe room rebate program that accepts applications. If accepted, the rebate provides offers up to $2000 per home, or up to 75% of the cost of the safe room or shelter.

Likewise, successful collaboration before the outbreak event helped to save many lives. The OK-First program, an Oklahoma Mesonet outreach and weather education program to Emergency Managers and Law Enforcement personnel in Oklahoma, added Assistants' Workshops to its training catalog in 1999, which provided radar and weather basics education to staff that support OK-First participant. OK-First participants and their staff used their training to save lives during the May 3, 1999 tornado outbreak, showcasing the crucial need to train and educate emergency managers and law enforcement in the region.

NWS Norman May 3-4, 1999 Fast Facts: https://www.weather.gov/oun/events-19990503-fastfacts

Oklahoma SoonerSafe Rebate Program: https://www.ok.gov/OEM/saferoom/app/

OK-First Outreach Program: http://www.mesonet.org/index.php/okfirst

Are there trends in the heaviest hourly periods with rainfall?

Vincent Brown, SCIPP Research Assistant/LSU Department of Geography

Extreme precipitation events have a large societal impact and appear to be increasing in many regions across the United States (Melillo et al. 2014; USGCRP 2017). In the past few years, there have been a number of extreme events that have resulted in dangerous floods across the Southeast. For example, Charleston, SC in 2015 (682.75 mm in 4-days), southern Louisiana in 2016 (797.3 mm in 2-days), Houston, Texas (Hurricane Harvey) in 2017 (> 1524 mm in 5-days), and Elizabethtown, NC (Hurricane Florence) in 2018 (> 889 mm in 4-days). While the Southeast is prone to these type of events, having experienced more billion-dollar disasters than any other region in the U.S. since 1980 (NCADAC 2013), the cost and impacts of extreme precipitation may become magnified in the future due to climate change (NCADAC 2013; Melillo et al. 2014).

Numerous studies have found or project statistically significant increases in the frequency of extreme precipitation (Kunkel et al. 1999; Trenberth et al. 2003; Groisman et al. 2005; Skeeter et al. 2019) and some suggest hourly extremes will change as well (Prein et al. 2017). It is known most severe and extreme storms contain short periods of intense rainfall (Muschinski and Katz 2013) that are not resolved when examining daily data. Daily and multi-day heavy and extreme events are increasing (see USCGCRP 2017), but it is not fully known if these events are also present at the hourly level. The goal of this research is to determine if the heaviest hourly events (i.e. the hours with the most accumulation per year) are increasing in magnitude from 1960—2017.

Hourly data from 50 first-order weather stations across the Southeast, defined as the 11-station region of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas, were collected from 1960—2017. Using the hourly data, annual time series were created for the greatest 1,3,6,12, and 18-hour accumulation in each year for each station. For example, the annual maximum 3-hour time series represents the greatest 3-hour period with rainfall in each year. These time series reflect the greatest hourly accumulation amounts per year and are worth examining to determine if they're increasing in conjunction with daily and multi-day extremes.

To test for trends in the time series, the non-parametric Mann-Kendall test for monotonic trends was used. The Mann-Kendall test uses the rank order of values and their order through time, via correlation, to determine if the data are randomly ordered independent (meaning there is no trend) (Hamed and Rao 1998). The Mann-Kendall was selected because the time series are highly variable and normality (on the residuals), via the Shapiro-Wilk test, was often rejected, making other methods such as regression, unsuitable.

Results revealed only eight of the fifty stations had significant trends in the five different annual hourly accumulation maximum series. Three stations had significant (defined as $p \leq 0.05$) increases in the one-hour maximum period; however, another four stations had increasing trends significant at the $0.05 \leq p \leq 0.10$ level (Figure 1a). Two (three) stations had significant trends (both increasing) in the three-hour (six-hour) maximum period with no coherent spatial pattern (Figure 1b and 1c). The twelve and eighteen-hour maximum periods yielded similar results (Figure 1d and 1e), with only four and three stations showing statistically significant trends, respectively. Out of the 250 Mann-Kendall tests run (50 stations and five different hourly periods), only 31 were significant (at either the 0.05 or 0.05 ≤ p. ≤ 0.10 level); however, 28 of the 31 were increasing, showing there are some increases at stations across the Southeast.

Results somewhat contradict recent research that describe a broad and significant increase in magnitude at the daily and multi-day extremes. However, it is important to remember these time series are highly variable which can limit the detection of trends. It is also clear that this research only investigated the most extreme hourly events each year. Just because these events are not increasing as broadly as expected does not mean precipitation is not changing across the region. In fact, recent research by Brown et al. (In Review) found that hourly precipitation intensity and average hourly accumulations were broadly increasing across the same region, while the

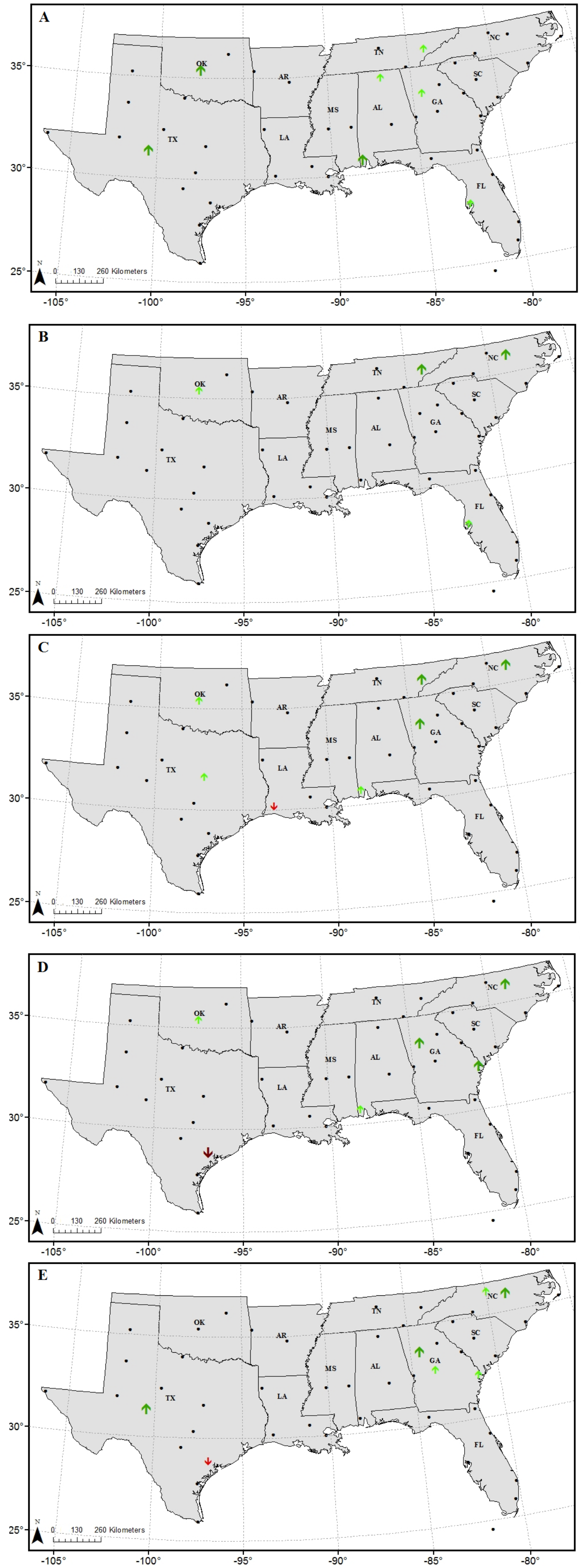

Figure 1. Trends (1960–2017) in annual hourly maximum precipitation periods for one-hour (A), three-hour (B), six-hour (C), twelve-hour (D), and eighteen-hour (E). Large darker green arrows represent increasing trends significant at the p. ≤ 0.05 level, smaller lighter green arrows represent increasing trends significant at the 0.05 ≤ p. ≤ 0.10 level. Large darker red arrows represent decreasing trends significant at the p. ≤ 0.05 level, smaller darker red arrows represent decreasing trends at the 0.05 ≤ p. ≤ 0.10 level. Black dots represent unsignificant stations.

average duration of precipitation events was significantly decreasing.

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Barry Keim

Barry Keim, Louisiana State Climatologist

Barry Keim grew up in Chalmette, Louisiana and become acquainted with severe weather at an early age. In fact, his earliest childhood memory is the day before his second birthday, which also happens to be the day before Hurricane Besty made landfall in southeastern Louisiana. Betsy flooded the New Orleans metro area including Chalmette, and his home took on four feet of storm surge water. Forty years later, hurricane Katrina flooding Chalmette again, this time putting 9 feet of water in Barry's childhood home. He also experienced numerous heavy rainfall events that paralyzed the city of New Orleans and thus experienced the power of Mother Nature firsthand.

Barry started out his college career at the University of New Orleans as a Geographer, but with interests more on the human end of the geographical spectrum. However, after being required to take a course on the Geography of the Atmosphere - which he did only because he had to - he fell in love with weather and wanted to pursue advanced degrees in weather and climate. He then did his MS and PhD degrees at Louisiana State University under the direction of Bob Muller, who at the time was the Louisiana State Climatologist. Barry's first job was on the faculty at the University of New Hampshire and as New Hampshire State Climatologist. He later moved back to his home state and alma mater and joined the faculty at LSU and took over as the Louisiana State Climatologist.

Over his career, he has published extensively in the areas of heavy rainfall, hurricanes and storm surge, interpretation of climate data, and perceptions of climate change. He is co-founder of the the database called SURGEDAT, which is a SCIPP product, serving as the most comprehensive storm surge database in existence. He engages at a high level with the media, doing between 100-200 media interviews annually. These interviews include stakeholders like the New York Times, NPR, PBS Newshour, the Washington Post, USA Today, the Weather Channel, and the Wall Street Journal, to name a few. He also served at the Chair of the Climate Specialty Group of the Association of American Geographers, which is likely the largest organization of the climatologists in the world.

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From Our Partners

USDA Southern Plains Climate Hub

Members of the USDA Southern Plains Climate Hub team have recently published several new scientific papers. These include an analysis of trends in intense precipitation across the United States (Climate); generation of synthetic daily weather data for use in climate change scenarios (Environmental and Natural Resources Research); and an evaluation of regional climate services activities across the Americas (Climate Services). More information about the Southern Plains Climate Hub and its science, technology, and outreach programs is available online.

if you have any further questions, contact Dr. David Brown, Director of the USDA Southern Plains Climate Hub at David.Brown@ARS.USDA.GOV.

Contact Us

To provide feedback or suggestions to improve the content provided in the Monitor, please contact us at monitor@southernclimate.org. We look forward to hearing from you and tailoring the Monitor to better serve you. You can also find us online at www.srcc.lsu.edu & www.southernclimate.org.

For any questions pertaining to historical climate data across the states of Oklahoma, Texas, Arkansas, Louisiana, Mississippi, or Tennessee, please contact the Southern Regional Climate Center at (225)578-5021.

For questions or inquiries regarding research, experimental tool development, and engagement activities at the Southern Climate Impacts Planning Program, please contact us at (405)325-7809 or (225)578-8374.

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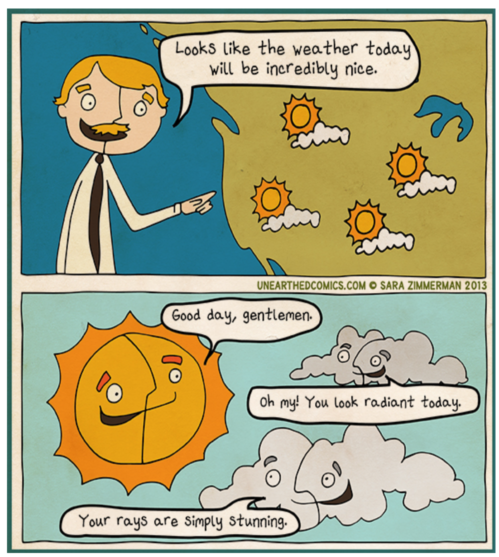

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